CLAIMS

What is claimed is:

1. A chip-based capillary electrophoresis assembly comprising:

a holder including a frame for removably receiving a chip;

a capillary electrophoresis microchip dimensioned to fit onto the holder, and comprising a body and a separation channel defined in the body; and

a pair of adhesive detection electrodes integrated with an electronic conductometric detection circuit, wherein the assembly is assemblable by disposing the capillary electrophoresis microchip on the holder and removably placing the adhesive electrodes on the microchip body near the separation channel.

2. A capillary electrophoresis assembly as recited in claim 1, wherein the holder further includes a Faradaic shield disposed on the frame between the electrodes when the capillary electrophoresis microchip is disposed on the frame and the electrodes are placed on the microchip body.

3. A capillary electrophoresis assembly as recited in claim 2, wherein the holder further includes a clamp attachable to the microchip body, wherein the clamp serves to hold the capillary electrophoresis chip on the holder when the assembly is fully assembled.

4. A capillary electrophoresis assembly as recited in claim 1, wherein the adhesive detection electrodes are self-adhesive tape electrodes applied to the holder so when the microchip is assembled on the holder, the detection electrodes are on an undersurface of the microchip.

5. A capillary electrophoresis assembly as recited in claim 1, wherein the electronic conductometric detection circuit further comprises an ac function generator connected to, and amplified by, an amplifier, wherein the electronic conductometric

detection circuit applies a peak-to-peak actuation voltage amplitude of about 250-500 V to one of the detection electrodes.

6. A capillary electrophoresis assembly as recited in claim 5, wherein the separation channel has a semicircular cross-section width of about 50 μm, and the ac function generator amplified by the amplifier provides a peak-to-peak voltage of about 500 V at a frequency of about 50 kHz.

7. A capillary electrophoresis assembly as recited in claim 5, wherein the electronic conductometric detection circuit further comprises a current-to-voltage converter connected to the other one of the detection electrodes and a rectification, low-pass filtering, and offset circuit connected to the current-to-voltage converter.

8. A capillary electrophoresis assembly as recited in claim 1, wherein the holder further includes a recess defined in the frame for removably receiving the microchip, wherein the recess is defined by a recessed floor in the frame of the holder, and the recess is dimensioned to receive the microchip, and the pair of detection electrodes are disposed on the recessed floor so that when the microchip is assembled in the recess of the holder frame, the electrodes are disposed to cross under the separation channel.

9. A chip-based capillary electrophoresis assembly comprising:

a holder including a frame for removably receiving a chip;

a capillary electrophoresis microchip dimensioned to fit onto the holder, and comprising a body, a separation channel defined in the body, and a pair of grooves formed in an outer surface of the body, wherein the grooves are disposed to cross over the separation channel; and

a pair of adhesive detection electrodes integrated with an electronic conductometric detection circuit, wherein the assembly is assemblable by disposing the capillary electrophoresis microchip on the holder and removably placing the adhesive electrodes on the microchip body in the grooves near the separation channel.

10. A capillary electrophoresis assembly as recited in claim 9, wherein each groove has a floor, and when the assembly is fully assembled one of the adhesive electrodes coheres to the floor of each groove.

11. A chip-based capillary electrophoresis assembly comprising:

a holder including a frame for removably receiving a chip;

a capillary electrophoresis microchip dimensioned to fit onto the holder, and comprising a body, a separation channel defined in the body, and a plurality of grooves formed on the surface of the body;

an electronic conductometric detection circuit; and

a detection electrode disposed in each groove, wherein each electrode is connected to the electronic conductometric detection circuit, and wherein the assembly is assemblable by disposing the capillary electrophoresis microchip on the holder.

12. A capillary electrophoresis assembly as recited in claim 11, wherein each detection electrode is an adhesive electrode integrated with the electronic conductometric circuit and the assembly is assemblable by removably placing each detection electrode into one of the grooves on the microchip body.

13. A capillary electrophoresis assembly as recited in claim 11, wherein each groove has a floor and each electrode comprises conductive paint painted on the floor of one of the grooves.

14. An electrodeless capillary electrophoresis microchip comprising:

a body; and

a separation channel formed in the body.

15. An electrodeless capillary electrophoresis microchip as recited in claim 14, further comprising: an injection cross formed in the body so as to be contiguous with the separation channel, and at least one well formed in the body so as to be contiguous with the injection cross.

16. An electrodeless capillary electrophoresis microchip as recited in claim 14, further comprising a first groove formed in a surface of the microchip so as to cross the separation channel and dimensioned so as to receive a removable actuator electrode.

17. An electrodeless capillary electrophoresis microchip as recited in claim 16, further comprising a second groove formed in a surface of the microchip so as to cross the separation channel and dimensioned so as to receive a removable pick-up electrode, wherein the first groove and the second groove are separated by a gap and are arranged anti-parallel to the separation channel.

18. An electrodeless capillary electrophoresis microchip as recited in claim 17, wherein the microchip is made of a material selected from the group consisting of glass and a synthetic polymer.

19. An electrodeless capillary electrophoresis microchip as recited in claim 18, wherein the microchip is made of the synthetic polymer, and the polymer is polymethylmethacrylate.

20. A capillary electrophoresis microchip consisting of:

a body;

a separation channel formed in the body;

an injection cross formed in the body and contiguous with the separation channel;

a plurality of sample reservoirs connected to the injection cross;

a run buffer reservoir connected to the injection cross; and

an outlet reservoir connected to the separation channel.

21. A capillary electrophoresis microchip as recited in claim 20, wherein the body is made of a material selected from the group consisting of glass and a synthetic polymer.

22. A capillary electrophoresis microchip as recited in claim 21, wherein the separation channel has either a semicircular, circular or rectangular cross section.

23. A micromachined capillary electrophoresis microchip comprising:

a body;

a separation channel formed in the body;

one or more grooves formed in a surface of the body, wherein each groove is arranged so as to cross over the separation channel; and

an electrode formed on a surface of each groove.

24. A micromachined capillary electrophoresis microchip as recited in claim 23, wherein each formed electrode is painted on the surface of the corresponding groove with conductive paint.

25. A micromachined capillary electrophoresis microchip as recited in claim 24, wherein the conductive paint is a conductive silver paint.

26. A micromachined capillary electrophoresis microchip as recited in claim 25, wherein each groove is formed in the body so as to cross over and above the separation channel, and each groove is orthogonal to the separation channel.

27. A micromachined capillary electrophoresis microchip as recited in claim 26, wherein each groove has a floor, and the floor of each grove is located approximately 0.2 mm from the separation channel.

28. A method of label-free analyte conductometric detection comprising the steps of:

(a) assembling a chip-based capillary electrophoresis assembly, the assembly comprising:

(i) a holder including a frame for removably receiving a chip;

(ii) a capillary electrophoresis microchip dimensioned to fit onto the holder, and comprising a body and a separation channel defined in the body; and

(iii) a pair of adhesive detection electrodes integrated with an electronic conductometric detection circuit, wherein the assembly is assemblable by disposing the capillary electrophoresis microchip on the holder and removably placing the adhesive electrodes on the microchip body so as to cross above or below the separation channel;

(b) injecting a sample containing an analyte into the separation channel;

(c) applying a separation potential between a pair of separation electrodes, wherein one of the pair of separation electrodes is disposed at each end of the separation channel, so that the analyte migrates along the separation channel;

(d) using a function generator integrated in the electronic conductometric detection circuit to apply a high voltage detection potential across the adhesive detection electrodes; and

(e) using the electronic conductometric detection circuit to detect the analyte when the analyte migrates by the detection electrodes.

29. A method as recited in claim 28, wherein the high voltage detection potential applied across the detection electrodes is an ac voltage having a peak-to-peak amplitude of between about 250-500 V and a frequency of between about 50-100 kHz.

30. A method as recited in claim 29, wherein the separation potential applied is a dc voltage having an amplitude of about 3-4 kV.

31. A method as recited in claim 30, wherein the injection of the sample containing the analyte includes applying an injection potential between a pair of injection electrodes for a predetermined period of time, wherein the injection potential is a dc voltage having an amplitude of about 1-2 kV.

32. A method as recited in claim 28, wherein the body of the microchip further includes a pair of grooves formed in a surface of the body so as to cross over the separation channel, and the chip-based assembly is assembled by placing one of the detection electrodes respectively in each one of the grooves.

33. A label-free capillary electrophoresis immunoassay method comprising the steps of:

(a) providing a capillary electrophoresis microchip comprising a body and a separation channel defined in the body, and providing a pair of detection electrodes connected to an electronic conductometric detection circuit so the detection electrodes are placed on the microchip body so as to cross above or below the separation channel;

(b) injecting a first sample containing a first immunoglobulin into the separation channel;

(c) injecting a second sample containing a second immunoglobulin into the separation channel so the second immunoglobulin mixes with the first immunoglobulin; and

(d) reacting the first immunoglobulin with the second immunoglobulin within the separation channel to form an immunoglobulin complex.

34. A method as recited in claim 33, wherein the first sample is injected into the separation channel using a first dc voltage applied for a predetermined period of time.

35. A method as recited in claim 34, wherein the second sample is injected into the separation channel using a second dc voltage applied for a predetermined period of time.

36. A method as recited in claim 33, further comprising pre-conditioning the separation channel with a basic solution followed by rinsing of the separation channel with a run buffer before injecting either the first sample or the second sample into the separation channel.

37. A method as recited in claim 33, further comprising the step of applying a separation potential between a pair of separation electrodes, wherein one of the separation electrodes is disposed at each end of the separation channel so the immunoglobulin complex migrates along the separation channel.

38. A method as recited in claim 37, wherein the separation potential applied is a dc voltage.

39. A method as recited in claim 37, further comprising the step of applying a detection potential across the detection electrodes, wherein the detection potential is an ac voltage having a predetermined peak-to-peak amplitude and a predetermined frequency.

40. A method as recited in claim 39, wherein the detection potential has a peak-to-peak amplitude of 400 V and a frequency of 50 kHz.

41. A method as recited in claim 39, further comprising the step of using the electronic conductometric detection circuit to detect the immunoglobulin complex as the complex migrates by the detection electrodes.

42. A method as recited in claim 33, wherein the body of the microchip further includes a pair of grooves formed in a surface of the body so as to cross the separation channel, and the detection electrodes are adhesive electrodes, so when the detection electrodes are placed on the microchip body the electrodes are placed to detachably cohere to a floor of each respective groove.

43. A method as recited in claim 33, wherein the microchip body is made of glass and the first sample and the second sample each include a run buffer and a surfactant to decrease adherence of the immunoglobulin complex to a wall in the body forming the separation channel.

44. A method as recited in claim 43, wherein the run buffer has a pH greater than an isoelectric point of the first immunoglobulin and an isoelectric point of the second immunoglobulin so as to decrease adherence of each immunoglobulin to the wall in the body forming the separation channel.

45. A method as recited in claim 41, wherein the time period between forming the immunoglobulin complex in the separation channel and detecting the immunoglobulin complex using the detection circuit is less than one minute.

46. A method as recited in claim 33, wherein the first immunoglobulin is IgM and the second immunoglobulin is IgG.

47. A capillary electrophoresis assembly comprising:

a holder including a frame for removably receiving a chip;

a capillary electrophoresis microchip dimensioned to fit onto the holder, and comprising a body and a separation channel defined in the body; and

a pair of detection electrodes integrated with an electronic conductometric detection circuit, wherein the detection electrodes are permanently affixed to the holder, wherein the assembly is assemblable by disposing the capillary electrophoresis microchip on the holder so the detection electrodes are disposed on the microchip body near the separation channel.

48. A capillary electrophoresis assembly as recited in claim 47, wherein the detection electrodes are affixed to the holder so when the microchip is assembled on the holder, the detection electrodes are disposed on an undersurface of the microchip.

49. A capillary electrophoresis assembly as recited in claim 47, wherein the holder further comprises an electrode support member attachable to the microchip body, and the detection electrodes are permanently affixed to the electrode support member so when the microchip is assembled on the holder, the electrode support member attaches to

the microchip body and the detection electrodes are disposed on a top surface of the microchip.